Performing mineral hydration experiments in the CheMin diffractometer on Mars

Session P009: Experimental Planetary Geochemistry: Simulating planetary processes on the Moon, Mars and other rocky bodies in the Solar System.

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Laboratory work is the cornerstone of experimental planetary geochemistry, mineralogy, and petrology, but much is to be gained by "experiments" while on a planet surface. Earth-bound experiments are often limited in ability to control multiple conditions relevant to planetary bodies (e.g. cycles in temperature and vapor pressure of water), but observations on-planet provide a unique opportunity where conditions are native to the planet and those affected by sampling and analysis can be constrained. The CheMin XRD instrument on Mars Science Laboratory has been able to test mineral hydration in samples held for up to 300 Mars days (sols). Clay minerals sampled at Yellowknife Bay early in the mission had both collapsed (10 Å) and expanded (13.2 Å) basal spacing. Collapsed interlayers were expected, but larger spacing was not; it was uncertain whether larger basal spacing would collapse on prolonged exposure to warmer conditions inside CheMin. Observation over several hundred sols showed no collapse, with the conclusion that expanded interlayer spacing was due to partial intercalation by metal-hydroxyl groups that resist dehydration. More recently, a sample of the Murray Formation, Oudam, provided the first XRD detection of gypsum and a chance to observe gypsum stability. Laboratory work suggests gypsum should be stable at Mars surface conditions, and indeed gypsum has been observed from orbit at higher latitudes and in thick veins at Yellowknife Bay by Mastcam reflectance spectra. Laboratory experiments have shown that on dehydration the gypsum would not become X-ray amorphous but would rather transform to a water-deficient bassanite structure. Over a period of 37 sols, it was observed that the Oudam sample in CheMin transformed from an assemblage of gypsum+anhydrite, to gypsum+bassanite+anhydrite, and finally to bassanite+anhydrite. Mg-sulfates were also anticipated but have not been observed in CheMin despite chemical evidence for their presence. Unlike gypsum, hydrated Mg-sulfates can transition to an X-ray amorphous form. Crystalline Mg-sulfates are expected higher in the section on Mount Sharp, where it should be possible to determine whether they persist or are destabilized after sampling, providing further insight into hydrous mineral stability at Mars near-equatorial conditions.